ITS (Intelligent Transportation Systems) Solutions

By Makoto MAEKAWA*

ABSTRACT Worldwide ITS goals for safety and environment have recently been set to quite a high level, such as zero fatalities or zero delays. In order to achieve these high level goals, we have to think ITS with the "ubiquitous" point of view, which aspires that human, road and vehicle are connected to the network organically. NEC is now developing ITS solutions not only to support customers in achieving these goals, but also to bring about a ubiquitous network society.

KEYWORDS **ITS, Probe Information System, Car-to-car communication, Fast IP handover, Pedestrian ITS**

1. INTRODUCTION

ITS projects to improve safety, transportation efficiency, comfort, environment and creating new business by means of integrating human, road and vehicle utilizing information technology have been conducted in Japan since 1995 by the Japanese Government. To improve the environment, there is VICS (Vehicle Information Communication System), a system that gathers traffic condition from roadside sensors, converts it to congestion data, transmits it vehicles, where it is displayed on the navigation system screen. VICS infrastructure has been introduced all over Japan, and there are now more than nine million VICS terminals. Drivers can obtain real time congestion information and avoid the congested area. ETC (Electronic Toll Collection) has also been introduced on national highways across the country. There are now more than three million ETC terminals in use. ETC contributes greatly to the reduction of tollgate congestion.

From the perspective of safety, "passive safety," which focuses on safety after the crash, measures such as airbags, seat belts and so on have greatly contributed to the reduction of fatalities. But recently, America has introduced a concept called "Vision Zero," which means zero fatalities and zero delays. Europe also has introduced its "e-Safety" concept of reducing half the fatalities by 2010. To realize these safety goals, "active safety", which focuses on safety before the crash by gathering crucial information from surrounding vehicles or from the nearest roadside infrastructure, is essential. In addition, it would be impossible to achieve the congestion reduction goal only by means of information gathered by the infrastructure; information from traveling vehicles is essential.

To enhance ITS function as described above would require all cars to be connected to a network; in other words, the advent of ubiquitous network society is essential. In a ubiquitous society not only will many things become more convenient than now, but also the value of the network itself will become more valuable than ever. And this will be the essence of ubiquitous network society, and the form of social infrastructure itself will be affected greatly. This paper introduces some of the NEC's ubiquitous ITS activities.

2. NEC ACTIVITIES

NEC is developing ITS technologies and applications based on "ubiquitous" point of view. The following four items are the focal points:

2.1 Probe Information System

The Probe Information System is a system that regards the vehicle as a moving sensor. Vehicles have more than one hundred twenty (120) sensors including the results of drivers' and passengers' actions like turning on lights, windshield wipers. The capabilities of the system will continually be upgraded as time goes on.

If such information can be gathered and statistically processed it will be very useful. For example, vehicle speed data can be converted into traffic information, wiper information can be converted to rainfall information, and ABS information can be converted to road condition information (See **Fig. 1**).

NEC participated in the Probe Information System

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project led by the Japan Automobile Research Institute from 1999 to 2001. NEC also participated in the Internet ITS project led by the Ministry of Economy, Trade and Industry advised by Professor Murai of Keio University in 2001. In this project, 1,500 taxies functioned as probe vehicles in the Nagoya area. **Figure 2** shows real time traffic conditions gathered from speed data from the 1,500 taxies. Compared with VICS, the Probe Information System can provide more detailed information because on the one hand VICS data is gathered through sensors installed on main thoroughfares whereas on the other hand sensor vehicles can send real time information anywhere as long as a cellular phone is activated.

The essence of Probe Information System is to add value to the data gathered through network, so in this point of view, data mining technology developed by NEC laboratory can be applied in various ways. For

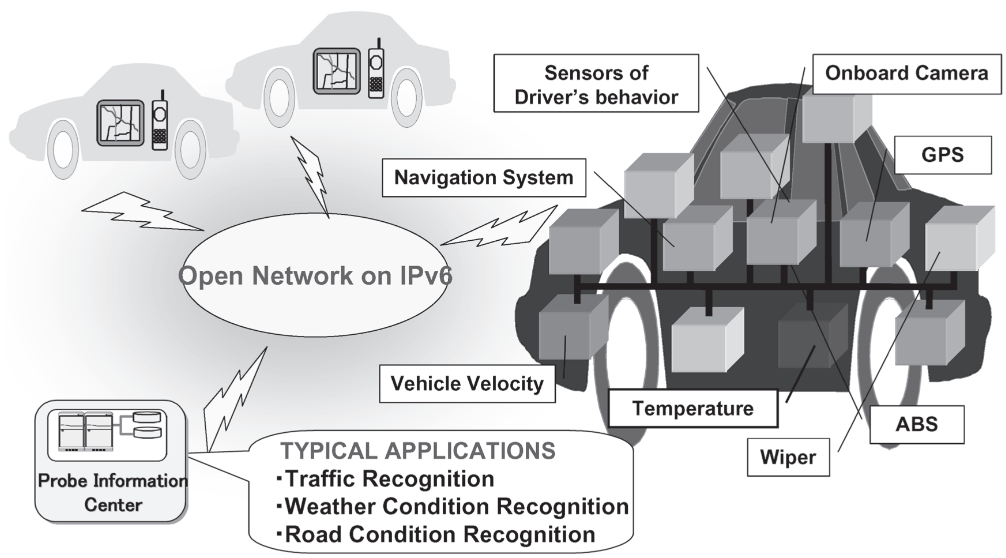


Fig. 1 Probe Information System.

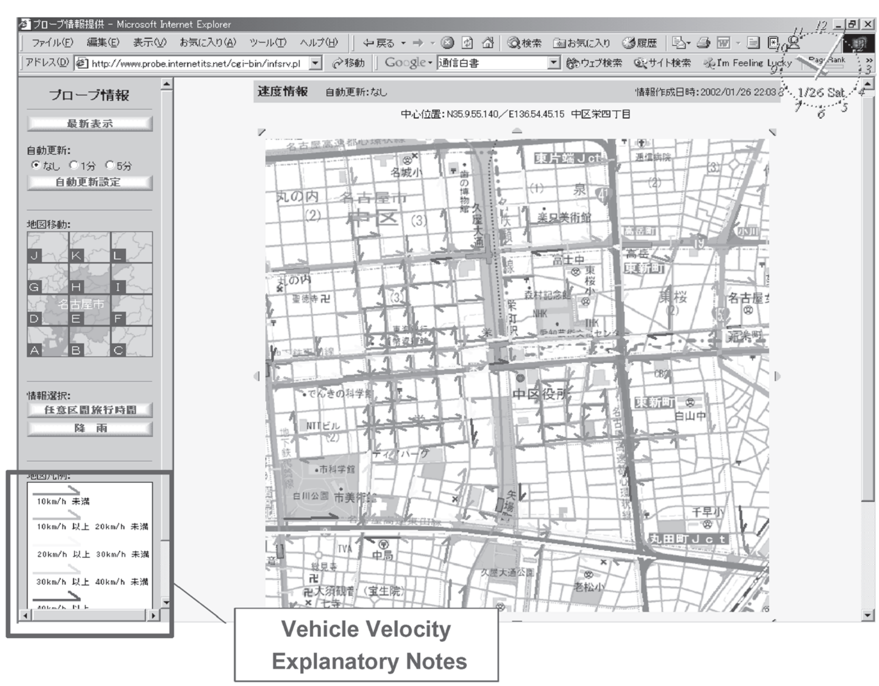


Fig. 2 Traffic congestion information using vehicle velocity.

example, traveling time from one point to another point according to time of the day, week, month can be estimated by mining past probe data.

Also it can be applied to analyze the congestion occurrence pattern and road expanding plans. **Figure 3** shows the result of adapting data mining technology to the estimation of travel time between Nagoya airport and center of the city of Nagoya. It also shows that the preciseness has been improved to one digital order. The Probe Information System is a state-of-the-art technology, which realizes many things that thought to be difficult to achieve and now is paid attention by all over the world.

2.2 FleetNet — Car-to-Car Communication

Safe driving can be significantly increased by using information from other vehicles. Such information can be conveyed via direct or indirect car-to-car communication, which has increasingly become a subject for global research. In this context, NEC Europe Network Laboratories has participated in the collaborative project FleetNet led by DaimlerChrysler and partially funded by the German Ministry of Education and Research BMBF. NEC was responsible for the routing protocol and chose position-based ad hoc routing as the key technology particularly suited for a highly dynamic environment.

As shown in **Fig. 4**, FleetNet regards car-to-car and car-to-roadside communication as within the same framework with the following four types of communication:

1) Car-to-car direct communication
2) Car-to-car communication via relaying by intermediate cars
3) Car to stationary FleetNet gateway
4) Car-to-Internet via stationary FleetNet gateway

Applications for these communication types are, for example, cooperative driver assistance, decentralized probe car, user communication and information services.

The core of this system is position-based routing. To avoid accidents or crashes, FleetNet cars send emergency warnings to cars in the rear based on their position, a technique called “geocast.” Packets are forwarded via the reachable car that is nearest the target area or car. This allows for a rapidly changing car and thus network topology, because cars are constantly updated about the current position of reachable (neighbour) cars by regular beacons. This makes position-based routing an appropriate choice for inter-vehicular communication. Simulation results in **Fig. 5** show that position-based approach has better packet delivery rates than conventional ad-hoc communication methods.

The results of the FleetNet project will be taken up by a new collaborative research project called NoW (Network on Wheels), which has new partners, such as BMW and Volkswagen. The goal is to advance

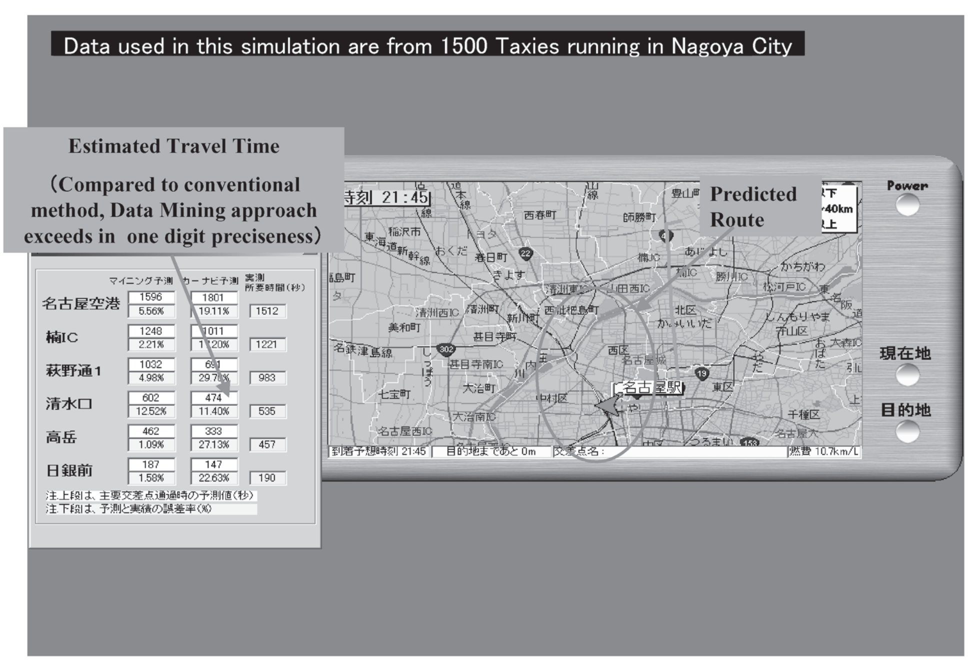


Fig. 3 Estimation of travel time.

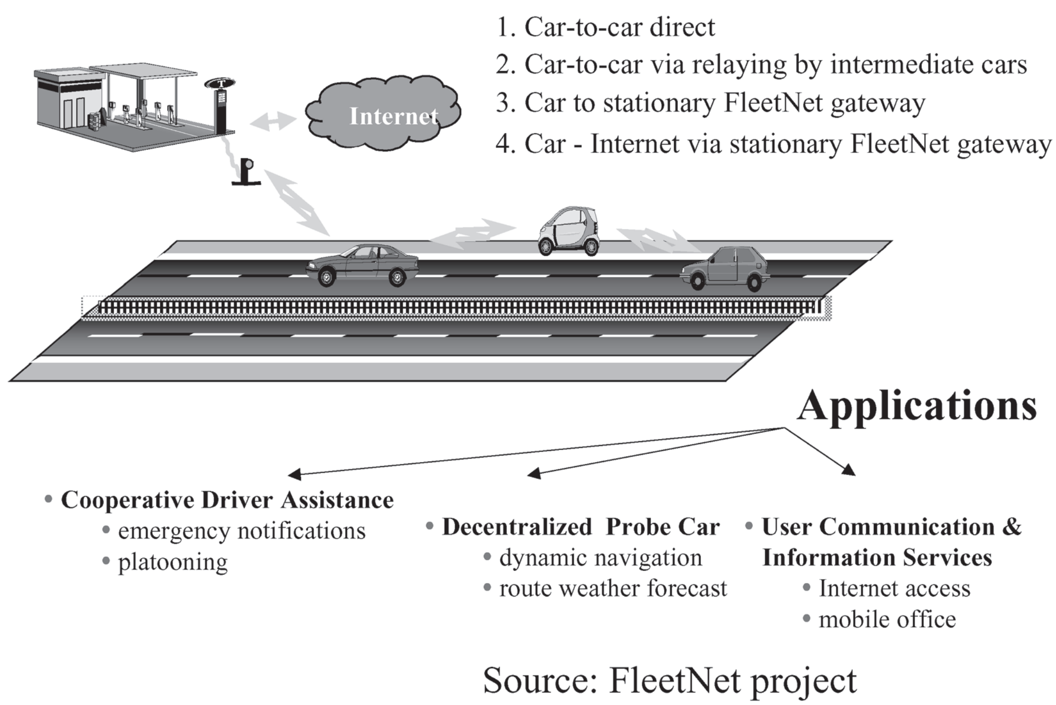


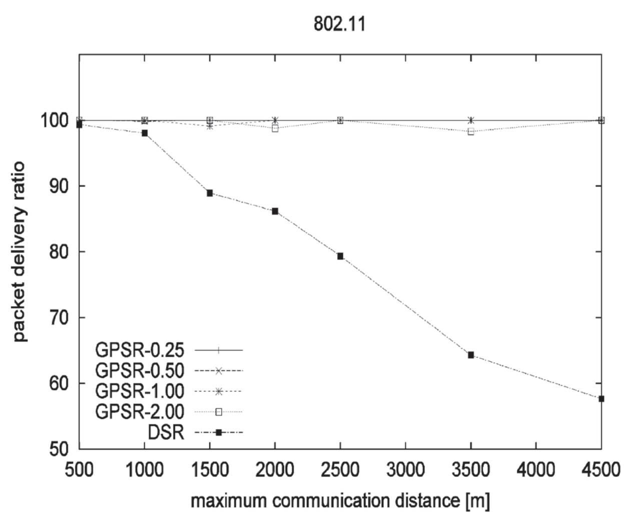
Fig. 4 FleetNet: Inter-vehicle communications platform.

towards the product stage with focus on testing and enhancing robustness under real-world conditions and a strong emphasis on security and dependability.

2.3 Fast IP Handover

The most popular communication media for moving vehicle is currently the cellular telephone, but there is a strong demand for higher speed communication media. It is possible to realize fast communication if wireless LAN can communicate seamlessly. To download high volume contents like moving pictures or music while moving fast on a train or on a car, handover among wireless LAN technology is essential. Fast IP Handover technology realizes handover at the IP layer. Since handover is accomplished at the IP layer, it can be applied to any communication media, even a new wireless technology can be applied.

To communicate seamlessly over a quite long distance (more than 100km), we have applied a hierarchy structure for the routers. Thanks to this hierarchy structure, it is not necessary to register the car position information with all the routers. That is to say we can localize and minimize the update of routing information table, thus we can realize the Fast IP Handover. Also by sending the information to the next spot where the vehicle is supposed to pass, we can prevent packet loss. **Figure 6** shows the mechanism of the Fast IP Handover.



Source: FleetNet project

Fig. 5 Packet delivery ratio.

We have made an experiment to evaluate the Fast IP Handover at Japan Automobile Research Institute in September 2003. In this experiment we sent interactive moving picture between the test vehicle and the backyard system, while driving at 330km/h without missing a frame. **Figure 7** shows the experiment overview. After releasing the result of this experiment, we have received many responses from railroad

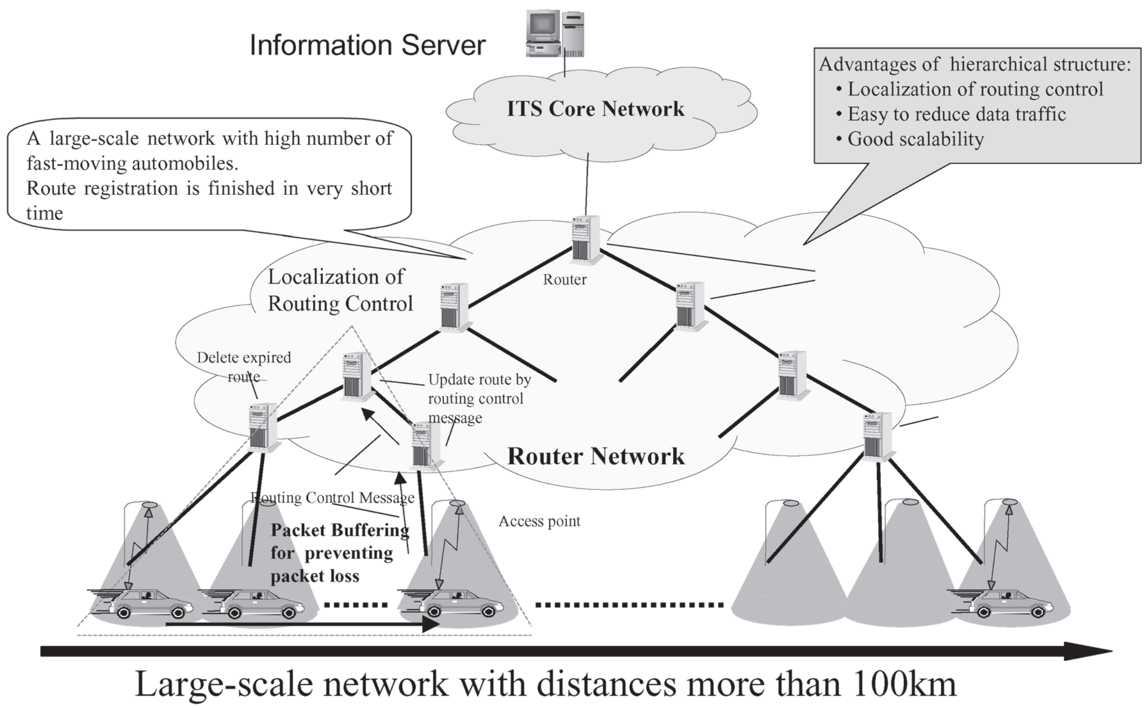


Fig. 6 Overview of IP hand-over technology.

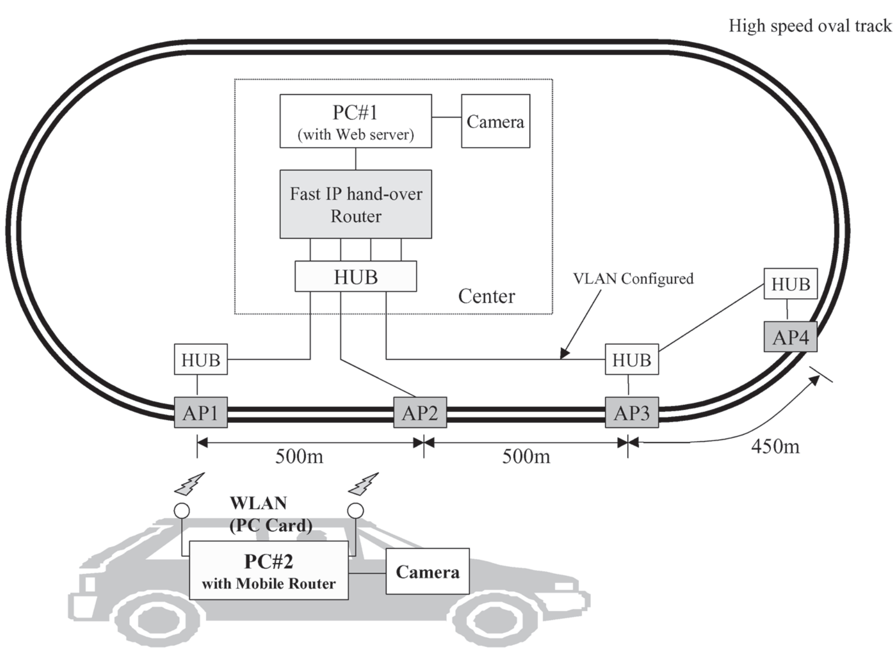


Fig. 7 Overview of the field test system.

companies and car companies.

2.4 Pedestrian ITS

In order to support pedestrians by providing route guidance and peripheral information, it is very important to allow them to obtain positional information. GPS-based positional information acquisition systems currently in common use have some problems regarding positional accuracy and speed. They cannot provide correct information for users at sidewalks between tall buildings, in underground shopping mall, or inside structures where large numbers

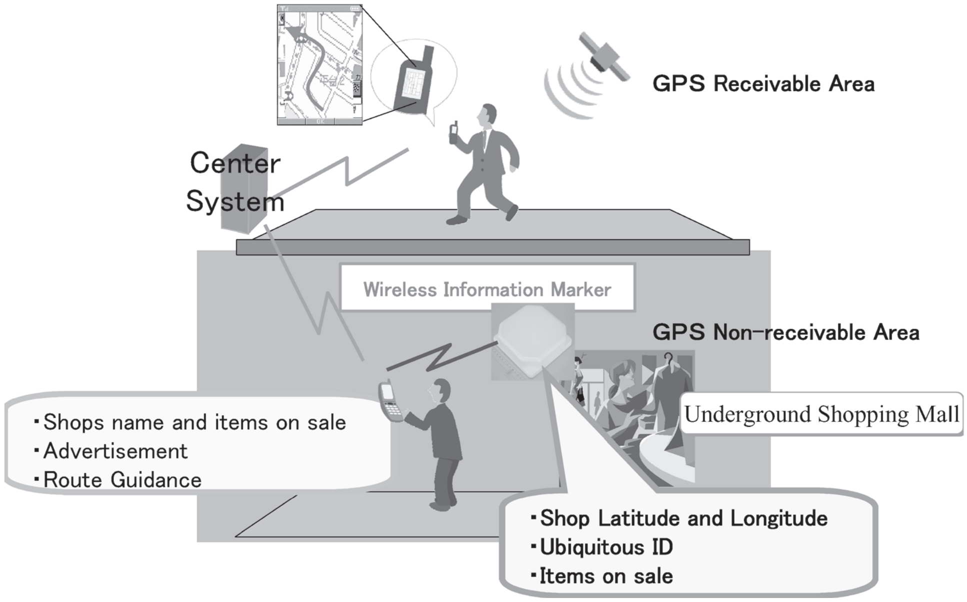


Fig. 8 Configuration of pedestrian ITS.

of people are walking around because multi-path transmissions from GPS satellites cause errors in accuracy and shields make it difficult to receive radio waves.

For solving these problems, we have employed wireless communication technologies for relatively short ranges as shown in **Fig. 8** to allow pedestrians having portable terminals to communicate with wireless communication devices transmitting positional information installed in roads, underground shopping areas, and the inside of buildings (we call these devices wireless information markers). As soon as connections are established in communication areas, this new system can provide the portable terminal's position to support the pedestrians. Installing the wireless information markers in appropriate places can solve the positioning accuracy and place-dependent positioning difficulty encountered in the conventional system.

In addition to positional information, a variety of other information can be received from wireless information markers, thereby increasing the range of services.

This system can cope with problems in conventional GPS and can be used as public infrastructure and as an advertising media for commercial facilities to enhance convenience for pedestrians.

3. CONCLUSION

The advent of ubiquitous network society is not far off, and we are heading toward to it in gradually but surely. ITS can play a large role in ubiquitous network society, and will contribute greatly to enhancing safety, environment and comfort. NEC will keep providing solutions for the ubiquitous ITS.

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